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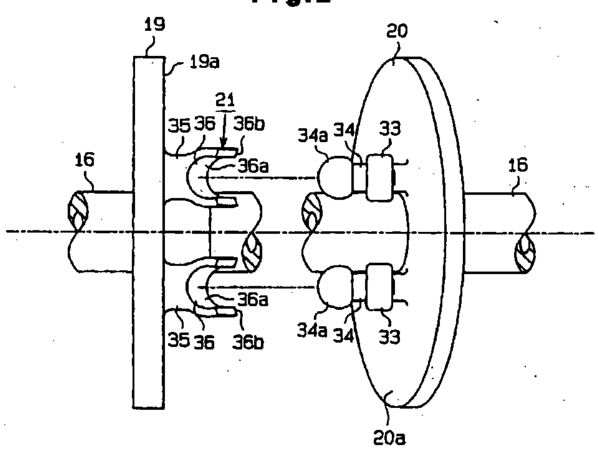
(54) Hinge mechanism for variable displacement compressors

(57) An improved variable displacement compressor has a drive shaft (16) extending through a crank chamber. A lug plate (19) is integrally fixed to the drive shaft (16). A drive plate (20) is connected to and driven by the lug plate (19) by a hinge mechanism (21). The drive plate (20) inclines with respect to the drive shaft (16) to vary the displacement of the compressor. The hinge mechanism (21) has a linear guide (19) on the lug plate (19) and a pin (34) projecting from the drive plate (20) toward the lug plate (19). A bearing surface (36a) engages the pin (34). The pin (34) has an axis (AXp) that intersects an axis (Axg) of the guide (19) . The axis (AXp) of the pin (34) is parallel to the axis (AXd) of the drive shaft (20) when the compressor operates with a maximum load.

Fig.2



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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a hinge mechanism for variable displacement compressors used in, for example, automobile air-conditioners.

[0002] A typical variable displacement compressor has a housing, which houses a crank chamber, and a cylinder block. A drive shaft extends through the crank chamber. Cylinder bores extending through the cylinder block accommodate pistons. A lug plate is fixed to the drive shaft to rotate integrally with the drive shaft. A swash plate, which drives the pistons, is located adjacent to the lug plate.

[0003] The lug plate is connected to the swash plate by a hinge mechanism. Each piston is coupled to the swash plate. In this structure, the difference between the pressure of the crank chamber and the pressure of the cylinder bores is altered by adjusting the size of the opening in a displacement control valve. The inclination of the swash plate changes in accordance with the pressure difference, the displacement of the compressor varies accordingly.

[0004] With reference to Fig. 4, a hinge mechanism 51, which enables a swash plate 54 to incline, includes a guide bore 53 formed on a rear surface 52a of a lug plate 52 and a pin 55 projecting from a front surface of the swash plate 54. The guide bore 53 is formed so that its axis AXg is inclined relative to the rear surface of the lug plate 52. The pin 55 has a spherical end portion 55a, which is received by the guide bore 53 and which slides along the guide bore 53 in the direction of the guide bore axis AXg.

[0005] When the compressor is operated, a compression load acts on the pin 55. This applies a bending moment M to a proximal end 55b of the pin 55. The bending moment M is calculated from equation (1).

$$M=Fa \cdot L=Fb \cdot \cos\theta \cdot L \qquad (1)$$

[0006] In the equation, Fa represents the force applied to the spherical portion 55a of the pin 55 by the compression load in a direction perpendicular to the pin axis AXp. Fb represents the force applied to the spherical portion 55a by the compression load in a direction perpendicular to the guide bore axis AXg. The symbol L represents the length of the pin 55 extending from the swash plate 54, and θ represents the angle between the pin axis AXp and the guide bore axis AXg. The angle θ is equivalent to the angle formed between the two forces Fa, Fb.

[0007] The length L of the pin 55 must be relatively long so that the pin 55 can move in the guide bore 53 for a distance that enables the swash plate 54 to move between a maximum inclination position and a minimum inclination position. Further, the angle θ between the pin axis AXp and the guide bore axis AXg must be minimized to avoid interference between the guide bore 53 and the pin 55. This results in a large force Fa being applied to the spherical portion 55a of the pin 55 by the compression load.

[0008] In the structure of Fig. 4, the bending moment M applied to the proximal end 55b of the pin 55 is large. Therefore, the pin 55 must be securely fixed to the swash plate 54 by press-fitting the proximal end 55b of the pin 55 into a retaining bore 54a of the swash plate 54. Therefore, the dimensions of the proximal end 55b and the retaining bore 54a must be accurate. Further, the diameter and length of the press-fitted portion including the proximal end 55b must be as large as possible. This enlarges the pin 55 and its surrounding components. As a result, the manufacturing cost increases, and the weight of the compressor increases.

[0009] Japanese Unexamined Patent Publication No. 10-54353 proposes a compressor in which the pin is located on the lug plate and received by a guide groove in the swash plate. The guide groove extends diagonally relative to the front surface of the swash plate. The pin slides in the axial direction of the guide groove, and the axes of the pin and guide groove intersect.

[0010] However, the guide groove must be long to enable the pin to slide between locations corresponding to the swash plate's maximum inclination position (where the displacement of the compressor is maximal) and minimum inclination position (where the displacement of the compressor is minimal). Thus, a large support must be provided on the front surface of the swash plate to form the guide groove. This increases the weight of the swash plate. In addition, the large support may cause a weight imbalance of the swash plate. This would result in inaccurate positioning, or inclination, of the swash plate when the displacement control valve alters the pressure difference between the crank chamber and the cylinder bores.

[0011] Furthermore, the pin extends from the rear surface of the lug plate toward a location on the swash plate corresponding to the top dead center position of the pistons. The angle of the pin relative to the drive shaft is always the same regardless of the compressor displacement. Thus, the bending moment at the proximal end of the pin increases as the compressor displacement increases.

SUMMARY OF THE INVENTION

[0012] It is an object of the present invention to provide a light and inexpensive variable displacement compressor that ensures satisfactory response to displacement control and simplifies the structure for fixing the pin to a drive plate.

[0013] To achieve the above object, the present invention provides a variable displacement compressor having a crank chamber and a plurality of cylinder bores within a housing. A rotary drive shaft extends through

ber 15. This adjusts the difference between the pressure of the crank chamber 15, which acts on the front of the pistons 22, and the pressure of the cylinder bores 12a, which acts on the rear of the pistons 22. The pressure difference adjustment changes the inclination of the swash plate 20, which in turn, alters the stroke of the pistons 22 and varies the displacement of the compressor.

[0025] When the solenoid 32a is de-excited, the valve body 32b opens the pressurizing passage 31 and connects the discharge chamber 25 to the crank chamber 15. This permits the high-pressure refrigerant gas in the discharge chamber 25 to flow into the crank chamber 15 through the pressurizing passage 31 and increases the pressure of the crank chamber 15. The increase of the crank chamber pressure increases the difference between the pressure applied to the pistons 22 by the crank chamber 15 and the pressure applied to the pistons 22 by the cylinder bores 12a. Consequently, the inclination of the swash plate 20 becomes minimal, as shown by the broken lines in Fig. 1, thus shortening the stroke of the pistons 22 and minimizing the displacement of the compressor.

[0026] When the solenoid 32a is excited, the valve body 32b closes the pressurizing passage 31 and disconnects the discharge chamber 25 from the crank chamber 15. This causes the pressure of the crank chamber 15, due to the release of gas into the suction chamber 24 through the bleeding passage 30, to decrease. The decrease of the crank chamber pressure decreases the difference between the pressure applied to the pistons 22 by the crank chamber 15 and the pressure applied to the pistons 22 by the cylinder bores 12a. Consequently, the inclination of the swash plate 20 becomes maximal, as shown by the solid lines in Fig. 1, thus lengthening the stroke of the pistons 22 and maximizing the displacement of the compressor.

[0027] The hinge mechanism 21 arranged between the lug plate 19 and the swash plate 20 will now be discussed in detail. With reference to Figs. 1 to 3, two brackets 33, which are spaced equally apart from the drive shaft 16, project from the front surface 20a of the swash plate 20. The point corresponding to the top dead center position on the swash plate 20 is located between the brackets 33. Each bracket 33 has a retaining bore 33a into which a proximal portion 34b of a pin 34 is press-fitted. A spherical portion 34a is formed at the distal end of each pin 34.

[0028] Two supports 35 project from the rear surface 19a of the lug plate 19 in association with the two pins 34. A guide 36 is defined on the distal end of each support 35. The guide 36 includes a bearing surface 36a, which has a generally semi-spherical cross-section, and a channel 36b, which receives the spherical portion 34a of the associated pin 34.

[0029] The axis AXg of the guide 36 is parallel to a plane including the axis AXd of the drive shaft 16 and the point on the swash plate 20 corresponding to the upper dead center position. Further, the axis AXg of the guide 36 is inclined so that the axis AXg is farther from the rear surface 19a of the lug plate 19 at locations closer to the drive shaft 16. Each pin 34 engages the associated bearing surface 36a, and the axis AXp of each pin 34 is substantially perpendicular to the axis AXg of the associated guide 36. Each pin 34 engages the corresponding bearing surface 36a so that the spherical portion 34a slides in the direction of the axis AXg.

[0030] When the swash plate 20 is arranged at the maximum inclination position, as shown by the solid line in Fig. 1, which maximizes the compressor displacement, the angle θ between the axis AXp of each pin 34 and the axis AXg of the associated guide 36 is closest to a right angle. Further, the axis AXp of the pin 34 is substantially parallel to the axis AXd of the drive shaft 16.

[0031] Accordingly, in the hinge mechanism 21, the pin 34 does not have to be extended in the direction of the axis AXg of the guide 36. Thus, the length L of the pin 34 can be relatively short. Further, the axis AXp of the pin 34 and the axis AXg of the guide 36 are nearly perpendicular (within the range of 45 to 90 degrees) when the swash plate 20 is fully inclined. Hence, the angle θ between the axis AXp of each pin 34 and the axis AXg of the associated guide 36 is large. This decreases the force Fa applied to the spherical portion 34a of the pin 34. Therefore, the bending moment M (obtained from equation (1)), which is applied to the proximal portion 34b of each pin 34 during operation of the compressor, is small even when a large compression load acts on the pin 34.

[0032] Accordingly, the structure that fixes the proximal portion 34b of each pin 34 to the swash plate 20 is simplified. Further, the dimensions of the proximal portions 34b of the pins 34 and the retaining bores 33a of the brackets 33 do not have to be accurate. The formation of a bulky support on the front surface 20a of the swash plate 20 is also not necessary. In addition, the press-fitted portions, which include the proximal portions 34b of the pins 34, can be smaller. This allows the pins 34 and their surrounding parts to have smaller dimensions. As a result, the structure for fixing the pins 34 is inexpensive. Further, the weight of the swash plate 20 and the whole compressor are decreased.

[0033] In addition, since the guides 36 are located on the lug plate 19, the formation of a large support on the front surface 20a of the swash plate 20, as in the compressor of Japanese Unexamined Patent Publication No. 10-54353, is unnecessary. In this manner, an imbalance in the weight of the swash plate 20 is avoided. Therefore, the swash plate 20 is inclined accurately to the desired position when the difference between the pressure of the crank chamber 15 acting on the pistons 22 and the pressure of the cylinder bores 12a acting on the pistons 22 changes. Accordingly, the compressor responds quickly to displacement control.

[0034] When the inclination of the swash plate 20 and the displacement are maximal, the axis AXp of each pin 34 is substantially parallel to the axis AXd of the drive shaft 16. Accordingly, when the displacement is maximal and the compression load acting on the pins 34 is maximal, the pin axes AXp are substantially parallel to the drive shaft axis AXd. In this state, the compression load acts in a direction coinciding with the axes AXp of the pins 34. This decreases the bending moment M applied to the proximal portions 34b of the pin 34 by the large compression loads produced when the compressor is operating in a maximum displacement state.

[0035] It should be apparent to those skilled in the art that the present invention may be embodied in many other specific forms without departing from the spirit or scope of the invention. Particularly, it should be understood that the present invention may be embodied in the following forms.

[0036] The illustrated embodiment may be modified by providing the lug plate 19 only one of the guides 36 and the swash plate 20 with only one of the pins 34.

[0037] Furthermore, the present invention may be applied to a compressor employing a wobble plate in lieu of the swash plate.

[0038] The present examples and embodiments are to be considered as illustrative and not restrictive, and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

[0039] An improved variable displacement compressor has a drive shaft (16) extending through a crank chamber. A lug plate (19) is integrally fixed to the drive shaft (16). A drive plate (20) is connected to and driven by the lug plate (19) by a hinge mechanism (21). The drive plate (20) inclines with respect to the drive shaft (16) to vary the displacement of the compressor. The hinge mechanism (21) has a linear guide (19) on the lug plate (19) and a pin (34) projecting from the drive plate (20) toward the lug plate (19). A bearing surface (36a) engages the pin (34). The pin (34) has an axis (AXp) that intersects an axis (Axg) of the guide (19). The axis (AXp) of the pin (34) is parallel to the axis (AXd) of the drive shaft (20) when the compressor operates with a maximum load.

Claims

1. A variable displacement compressor having a crank chamber (15) and a plurality of cylinder bores (12a) within a housing (11, 12, 13), wherein a rotary drive shaft (16) extends through the crank chamber and carries a lug plate (19) integrally rotatable with the drive shaft (16), wherein a drive plate (20) is disposed adjacent to the lug plate (19) and coupled to the lug plate (19) by a hinge mechanism (21) so as to be integrally rotatable with and inclinable in respect with the drive shaft (16), and wherein the displacement of the compressor varies according to an inclination of the drive plate (20) based on a pressure difference between the crank chamber (15) and each cylinder bore (12a), **characterized in that** said mechanism (21) has at least one guide (19) linearly extending in the lug plate (19) and at least one pin (34) projecting from the drive plate (20) toward the lug plate (19) and slidably contacting the guide (19), wherein an axis (Axg) of the pin (34) nearly perpendicularly extends to an axis (Axp) of the guide (19).the axis of the guide extends in a direction intersecting the axis of the pin

2. The compressor as set forth in Claim 1, **characterized in that** said guide (36) includes a channel (36b) for clamping the pin (34), wherein said channel (36b) has an inner supporting surface and wherein said pin (34) slidably engages the inner supporting surface.

3. The compressor as set forth in Claims 1 or 2, **characterized in that** at least one bracket (33) provided on the drive plate (20), said bracket (33) including a bore (33a), wherein said pin (34) has a proximal end (34a) press-fitted within the bore (33a).

4. The compressor as set forth in any one of the preceding claims, **characterized in that** said axis (Axp) of the pin (34) extends substantially parallelly with the axis of the drive shaft (16) when the compressor is driven at its maximum displacement.

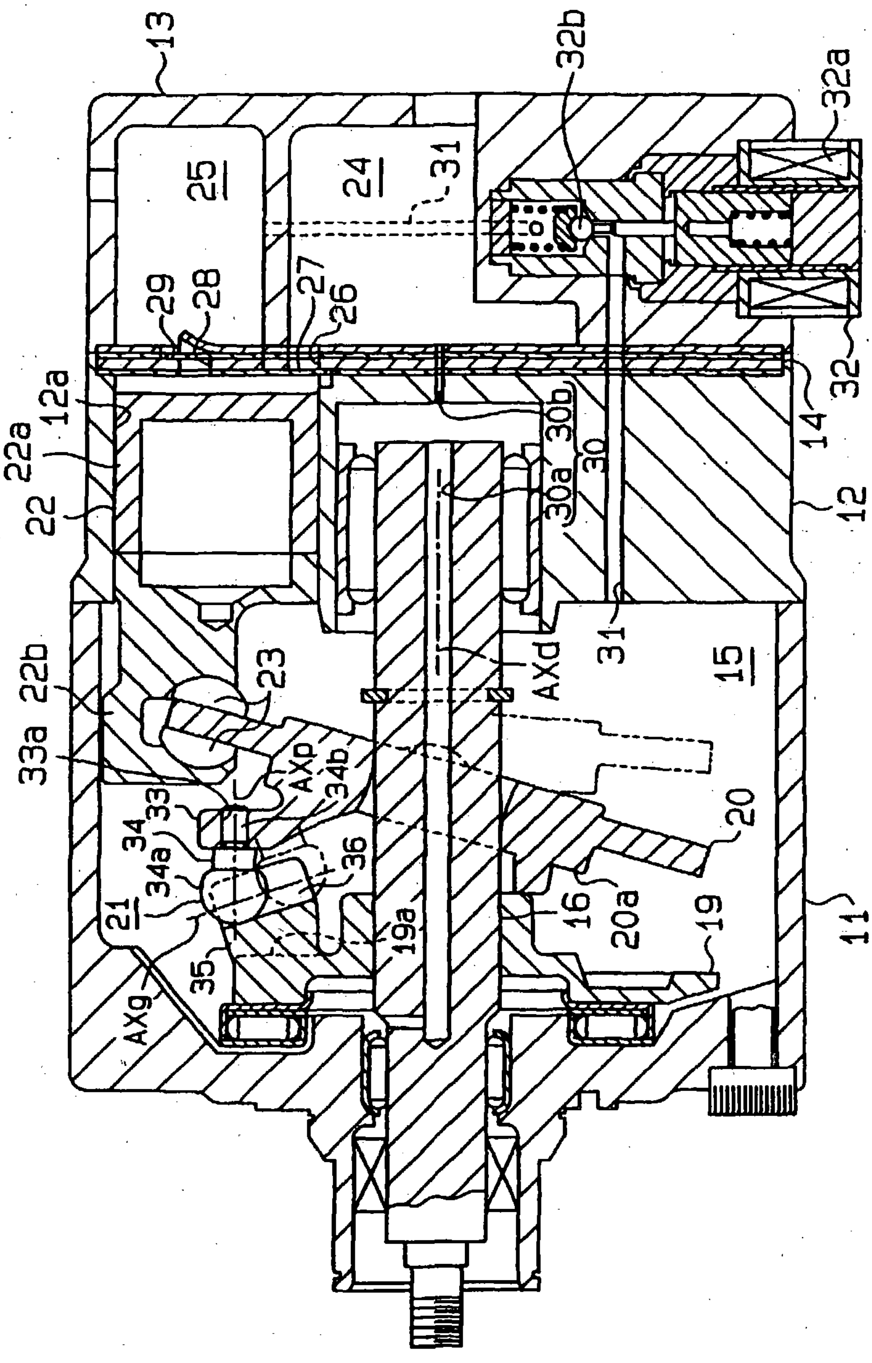
5. The compressor as set forth in any one of the preceding claims, **characterized by** a plurality of pistons (22), each coupled to the drive plate (20) and movable in the associated cylinder bore (12a) by a stroke based on the inclination of the drive plate (20), wherein said piston (22) has a first end surface directed to the crank chamber (15) and a second end surface directed to the cylinder bore (12a), and wherein the inclination of the drive plate (20) is subject to a difference between pressures respectively acting on the first end surface and the second end surface.

6. The compressor as set forth in any one of the preceding claims, **characterized by that** said pin (34) has a spherical portion (34a) at its distal end.

7. The compressor as set forth in any one the preceding claims, **characterized in that** said drive plate includes a swash plate (20).

8. The compressor as set forth in any one of the preceding claims, **characterized in that** the axis (AXg) of the guide (36) extends nearly perpendicular to the axis (AXp) of the pin (34) within a range of 45° to 90°.

Fig.1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AXp
34b
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34
34a
36
20
21
35
19a
16
20a
19
11
AXg

Fig.2